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Change of the Electrophysiological Function of Retina upon Decrease of Interalveolar Space in Patents with Major Dental Diseases

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Abstract: This study presents data on change of the electrophysiological function of retina as a reaction to the decrease of interalveolar space in patients with major dental diseases of various origin. Our electroretinographic study has revealed an improvement in the amplitudes of b-wave of maximum (total) ERG and b-wave of rod (scotopic) system of retina electrogenesis, a positive component reflecting the macula functioning (P50) and the improvement of the retinal ganglion cells functioning (3rd neuron of optic pathway) the amplitude of the negative component (N95) in patients upon restoration of the occlusal vertical dimension.

Key words: Ophthalmology, stomatology, function of the visual analyzer, electrogenesis retina, electroretinography, change in interalveolar distance

INTRODUCTION

Human visual analyzer is a complex neuro-receptor system that ensures both perception and analysis of light stimuli. The visual analyzer has three major divisions-receptor, conductive and cortical. The peripheral receptors of the retina ensure perception of light and the primary analysis of visual sensations. A conductive division includes optic pathways and oculomotor nerves. The cortical division of the analyzer located in the calcarine fissure of the occipital lobe receives pulses from both the retinal photoreceptors and proprioceptors of extraocular muscles and the muscles located in the iris and ciliary body. The nervous system is the main integrative system of the body which carries out its functions on the reflex principle. Moreover, the dento facial system is a powerful reflexogenic zone, where close associative and reflex bonds with other analytical systems through the blood supply and innervation. The result of the visual analyzer operation is the conversion of light energy into nerve process occurring in the sensory organ. Maxillofacial region is a complicated area that ensures implementation of various functions including communicative ones carried out by means of the visual analyzer, acoustic analyzer and speech production (Klineberg and Jager, 2008; Wilson-Pauwels, 2010; Bumann and Lotzmann, 2002; Fishman *et al*., 2001; Abrahamsson, 2013; Badel *et al*., 2008).

Objective of the study is to evaluate the functional status of the visual analyzer by recording the electroretinographic results in dental patients with signs of reduced interalveolar space.

MATERIALS AND RESEARCH METHODS

We examined 395 people aged from 32-68 years, with major dental diseases of a dento-facial system. The 293 (74.2%) patients of the total examined persons had signs of deep occlusion and formed the main group and 102 (25.8%) patients with no signs of deep occlusion formed the control group. The main group included 228 (77.8%) women and 65 (22.8%) men. The main dental diseases having resulted in a change in the jaw relationships were as follows: increased abrasion of hard tissues of teeth in 138 (47.1%) patients, a generalized periodontitis in 125 (42.6%) patients and partial loss of teeth in 260 (88.7%) patients. The 174 (59.4%) patients had a combination of major dental diseases revealed. We performed the determination of diseases by using International Classification of Diseases, 10th Edition (ICD-10). Exclusion criteria:

- Moderate and severe dysfunction of the temporomandibular joint as per Helcimo classification (1974)
- Somatic diseases in the decompensation phase
- A concomitant ophthalmic pathology (glaucoma, cataracts, diabetic and hypertensive retinopathy, acute vascular disorders, macular pathology etc.). The study was conducted in accordance with the declaration of Helsinki

The instrumental methods used were as follows:

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- Functional and physiological method of building constructive jaw relationships
- Extracranial and transcranial doppler sonography (ultrasound diagnostics) of vascular regions of the head and neck
- The method of electrophysiological study of retinal function Electroretinography (ERG) (Yamamoto *et al*., 1999)

Functional and physiological method allows taking into account the individual functionalities of a patient regardless of the severity level and degree of disease of dental components and identifying the response features of force characteristics.

We performed an assessment of four functional indicators of dento-facial system in 293 (74.2%) dental patients of the main group with impaired jaw relationships of different origin: maximum masticatory force, the type and displacement value of the mandible after the diagnostics, the integrated index of the maximum masticatory force depending on the separation of dental arch and the associated function of a neuromuscular system according to electromyography.

The patients of the main group had a decreased occlusal vertical dimension which varied from 0.5-5.5 mm. The 102 (25.8%) patients of control group had no reduction in the occlusal vertical dimension.

The study of cerebral hemodynamics with the use of ultrasound diagnostics revealed a dependence of the linear velocity of blood flow in a ofthalmica on the separation rate of the jaws in 231 (78.8%) patients. After the traditional methods of ophthalmological examination such as visometry, biomicroscopy and indirect binocular ophthalmoscopy (for avoidance of ophthalmic pathology), we have examined 198 patients which indicators met the inclusion and exclusion criteria.

We carried out an integrated assessment of the visual analyzer function by using techniques of computer aided perimetry and electrophysiological study of the retina (pattern ERG and EPS as per ISCEV standards).

We performed electrophysiological study before and after treatment to carry out a functional assessment of the retina in dental patients with signs of secondary reduced occlusion. Electroretinography (ERG) is a method of electrophysiological study of the functional status of the retina by recording the biopotentials occurring therein when exposed to light. Electroretinogram is a graphical representation of the electrical activity of the retina that occurs in response to light stimulation. ERG can be recorded in the entire area of the retina (the total (maximum) or ganzfeld ERG) and in the local area of various sizes. ERG represents the electrical activity of the majority of cellular elements of the retina and depends on the number of healthy neurons and photoreceptors.

The study was conducted with the use of the electrophysiological station Tomey EP 1000 Pro (Germany). EP 1000 Pro is an ophthalmological diagnostic tool designed for a full examination of functions of the retina, optic nerve and visual areas of the cerebral cortex. The methods applied are based on the detection of an electrical response to a specific light stimulus which meets the standards of the International Society for Clinical Electrophysiology of Vision (ISCEV).

ISCEV standards include rod ERG registration records, the maximum (total) ERG, Oscillatory Potentials (OPs), cone ERG and rhythmical ERG. We also studied the pattern of Electroretinography (ERG).

We used HK Loop Electrodes as active electrodes and skin electrodes AgCl (silver cup) as referent electrodes which were put in the outer can thus of the palpebral fissure and a reference electrode was fixed on the earlobe. ISCEV-standardized general electroretinography involves sequential operation.

Prior to the study, the patient underwent dark adaptation for 20 min to make the cone system of the retina stop functioning and only remain the rod system of the retina to operate. Further, we delivered the stimuli being sub-threshold for cone system with parameters, to which the rod cells respond. At the same time, both amplitude and b-wave latency were estimated. Recording was carried out with a faint blue or white flash with an energy below the cone threshold.

The next step involved studying the activity of all retinal cells (both cone and rod systems); for this purpose bright stimuli flashes were generated which all retinal cells were responded to. Prior to the study, a pupil was medically widened by instilling 1% mydriacyl solution. This part of study was aimed at assessing the amplitude and latency of a and b-waves. Recording of either maximum or general ERG was carried out by using standard stimuli of 1.5-4.5 cd/m^2 at an interval of 5-10 sec with the widened pupil.

Further, Oscillatory Potentials (OPs) were investigated. OPs are high frequency (100-160 Hz) rapid rhythmic waves of low amplitude on the ascending part of the ERG b-wave. Normal number of OPs in the ERG ranges 4-6. After the above studies, the patient was undergoing light adaptation within 10 min for suppressing the rod activity. Further, we conducted the study of cone system of the retina which results were recorded under photopic conditions (at a single stimulus with an interval of 0.5 sec on the light background suppressing the rod activity). First, a simple cone response was recorded and both amplitude and b-wave latency were estimated. Then, the

flashing, rhythmic stimuli with a given flicker frequency were delivered (a stimuli of 30 Hz was presented which ensured to assess the macular region).

The pattern ERG reflects primarily the activity of retinal ganglion cells and the functional status of the macular region. Values of the pattern ERG changes upon dysfunction of macular region and primary and secondary lesions of the optic nerve.

We also assessed two components of the pattern ERG: positive and negative. The positive component, lasting about 50 msec (P50), depends on the normal functioning of the macula and is sensitive to changes in the refraction. A large negative component, lasting about 95 msec (N95), reflects the status of ganglion cells (third neuron of optic pathway). The program of pattern ERG also studied the retinal response to a stimulus with a high flicker frequency a flicker showing the activity of the macular cones.

Graphical representation of the electrical activity of the visual organ is characterized by shape and two quantitative indices such as the amplitude (magnitude of response) and the latency (pulse propagation time).

Statistical processing was performed with the use of non-parametric methods of comparison: the Mann-Whitney U test for two independent groups and the Wilcoxon paired Ud test when assessing the values dynamics during prosthodontic treatment. Differences of $p \leq 0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

The results of electrophysiological study of the retina in dental patients with decreased interalveolar space of various origin are presented in Tables 1 and 2.

Standard values of the indicators: amplitude of maximum (general) ERG as per ISCEV standard: a-waves of the maximum (general) ERG = 130-160 mV; b-waves of the maximum (general) ERG = 250-300 mV; b-waves of the scotopic ERG = 90-100 mV; b-waves of the cone ERG = 90-100 mV. Pattern ERG, amplitude: P50=5-6 mV; N95=6-8 mV.

Table 1 shows that the reconstruction of the occlusal vertical dimension resulted in a statistically significant improvement ($p<0.05$) in the parameters of the b-wave amplitude. The value of b-wave amplitude on the general ERG increased from 200.8±17.52 to 255.6±10.8 mV which corresponded to the standard values. Neither latency nor amplitude of the a-wave had significant changes. Averages of b-wave amplitude of the scotopic system in habitual occlusion before treatment were 73.8±5.82 mV and increased to 96.2±6.23 mV ($p<0.05$) after the reconstruction of the occlusal vertical dimension that

Table 1: Findings of electrophysiological study of the retina (ISCEV-standardized ERG) in habitual occlusion and after treatment in dental patients with decreased interalveolar space (n = 198)

Retina EPS indices	In habitual occlusion before treatment	In optimal occlusion after treatment	p-values
a-wave latency (msec)	21.5±2.38	21.5±2.41	>0.05
a-wave amplitude (mV)	105.5±18.62	112.4±17.51	>0.05
b-wave latency (msec)	43±3.48	45.0±3.46	>0.05
b-wave amplitude (mV)	200.8±17.52	255.6±10.8	<0.05
b-wave latency of the scotopic system (msec)	75.1±8.52	81.4±9.24	>0.05
b-wave amplitude of the scotopic system (mV)	73.8±5.82	96.2±6.23	<0.05
b-wave latency of the cone system (msec)	29.5±3.25	31.1±3.46	>0.05
b-wave amplitude of the cone system (mV)	30.9±2.98	31.5±3.18	>0.0

Table 2: The pattern ERG values in patients with the reduced interalveolar space in habitual occlusion and after the reconstruction of the occlusal vertical dimension (n = 198)

Activity indices of the retinal ganglion cells	In habitual occlusion before treatment	In optimal occlusion after treatment	p-values
P50 latency (msec)	51.5±4.86	49.6±4.82	>0.05
P50 amplitude (mV)	3.2±0.27	5.0±0.38	<0.01
N95 latency (msec)	94.5±8.28	92.4±8.31	>0.05
N95 amplitude (mV)	5.1±1.05	7.4±0.80	<0.05

corresponded to the specified range. Both b-wave amplitude on the general ERG and b-wave amplitude of the scotopic system of the retina became more symmetric after the reconstruction of the occlusal vertical dimension. Other parameters remained virtually unchanged.

Analyzing the results presented in Table 2, we can conclude that the restoration of the occlusal vertical dimension improved the indicators of macula activity: there was a statistically significant increase from 3.2±0.27 to 5.0±0.38 mV ($p<0.01$) of the amplitude of the positive component of macula activity (P50) that reached the standard values; there was an improvement in the retinal ganglion cells activity (third neuron of optic pathway) the amplitude of the negative component (N95) increased after treatment from 5.1±1.05 to 7.40± 0.80 mV ($p<0.05$) which was seen as improved functioning of the visual analyzer. The pattern ERG values became more symmetric in both eyes which is the result of optimizing the linear blood flow velocity in the "head-neck" region. Other parameters of electrophysiological studies of the retina remained unchanged.

It is noteworthy that after the treatment, in addition to the increased values, both the amplitude of positive and negative components obtained from both eyes became more balanced than before treatment.

Treatment of patients with the decreased occlusal vertical dimension was conducted in comprehensive manner, taking into account the etiological factor, stage of

pathogenesis and the severity of the pathological process. Considering the pathological background state which serves the basis for the disease formation, this approach ensures maximum efficacy and safety of therapeutic measures. The treatment included both dental treatment and rehabilitation measures which were carried out by doctors of other disciplines. In the case of poor rehabilitation resource resulted from the unsatisfactory state of neurohumoral regulation, we applied a two-stage method of restoring the occlusal vertical dimension with the rigid plastic aligners under electromyographic control.

CONCLUSION

Restoration of the occlusal relationships with changing the occlusal vertical dimension results in a statistically significant increase ($p<0.05$) in values of the general electroretinography: b-wave amplitude of the general ERG and b-wave amplitude of scotopic electrogenesis of the retina. Post-treatment parameter values were in the specified range.

The treatment has led to the improvement of macula activity indicators: there was a statistically significant increase from 3.2±0.27-5.0±0.38 mV ($p<0.01$) of the amplitude of the positive component of macula activity (P50); there was an improvement in the retinal ganglion cells activity (3rd neuron of optic pathway) the amplitude of the negative component (N95) increased after treatment from 5.1±1.05-7.4±0.80 mV ($p<0.05$) which was seen as improved electrogenesis of the retina. The pattern ERG values became more symmetric in both eyes which evidenced the positive effect of the dento-facial elements on the function of the visual analyzer.

A clinical situation resulting in the reduced jaw relationships must be considered as a part of complex of interrelated pathological processes rather than an individual problem.

A comprehensive approach to the treatment of dental patients with signs of impaired jaw relationship of various origin will ensure a full range of diagnostic measures and adequate dental treatment based on somatic symptoms in patients with occlusal disharmony. A systemic approach to therapeutic interventions allows preventing the development of other ophthalmic and dental diseases.

REFERENCES

Abrahamsson, C., 2013. Masticatory function and temporomandibular disorders in patients with dentofacial deformities. Swed. Dent. J. Suppl., 231: 9-85.

Badel, T., M. Marotti, I. Krolo, J. Kern and J. Keros, 2008. Occlusion in patients with temporomandibular joint anterior disk displacement. Acta. Clin. Croat., 47: 129-136.

Bumann, A. and U. Lotzmann, 2002. TMJ Disorders and Orofacial Pain: The Role of Dentisitry in a Multidisciplinary Diagnostic Approach. Thieme, New York, USA., Pages: 360.

Fishman, G.A., D. Birch, G.E. Holder, M.G. Brigel, 2001. Electrophysiologic Testing. 2nd Edn., The Foundation of the American Academy of Ophthalmol, USA., Pages: 307.

Klineberg, I. and R. Jager, 2008. Occlusion and Clinical Practice. MED Press, Russia Pages: 200.

Wilson-Pauwels, L., 2010. Cranial Nerves: Function and Dysfunction. PMPH., USA., Pages: 272.

Yamamoto, S., M. Hayashi and S. Takeuchi, 1999. Electroretinograms and visual evoked potentials elicited by spectral stimuli in a patient with enhanced S-cone syndrome. Jpn. J. Ophthalmol., 43: 433-437.